



Comparative Technology Assessment White-paper





GC is an innovative advanced materials engineering company, driven by an ethos to create life-changing products.

As a world leader in advanced material research, development and design, we apply our advanced material expertise to a wide range of applications, developing breakthrough solutions to enhance product performance.

“From theory to R&D, and from testing to production, GC helps global brands unlock the potential of advanced materials engineering to bring world-changing products to life.”

- Sandy Chen, CEO



There is an acute focus by government and health institutions globally, such as the WHO and the CDC, on good quality air to improve indoor ventilation and in particular, to reduce exposure to airborne pathogens like SARS-CoV-2.

If a person with COVID-19 is in a room, infectious virus particles will move around the space, infecting others particularly where indoor air is being recirculated. Similarly, ventilation in one room may carry infectious viruses into connected rooms through HVAC vents that serve multiple rooms - common in schools, hospitals and office buildings.

And that's where virucidal filtration comes in.

Learning how to clean the air of potentially virus-laden aerosols would have long-term benefits for health and allow businesses and schools to remain open during future outbreaks and enable safe travel.

Clean Air - choosing the right solution

There are a lot of companies that claim their technology provides covid-killing solutions for homes and buildings - choosing the right solution can be bewildering and complex, so here we set out the main technologies that exist, how they work and break down the facts. For more detail please refer to the EPA summary of air cleaners.



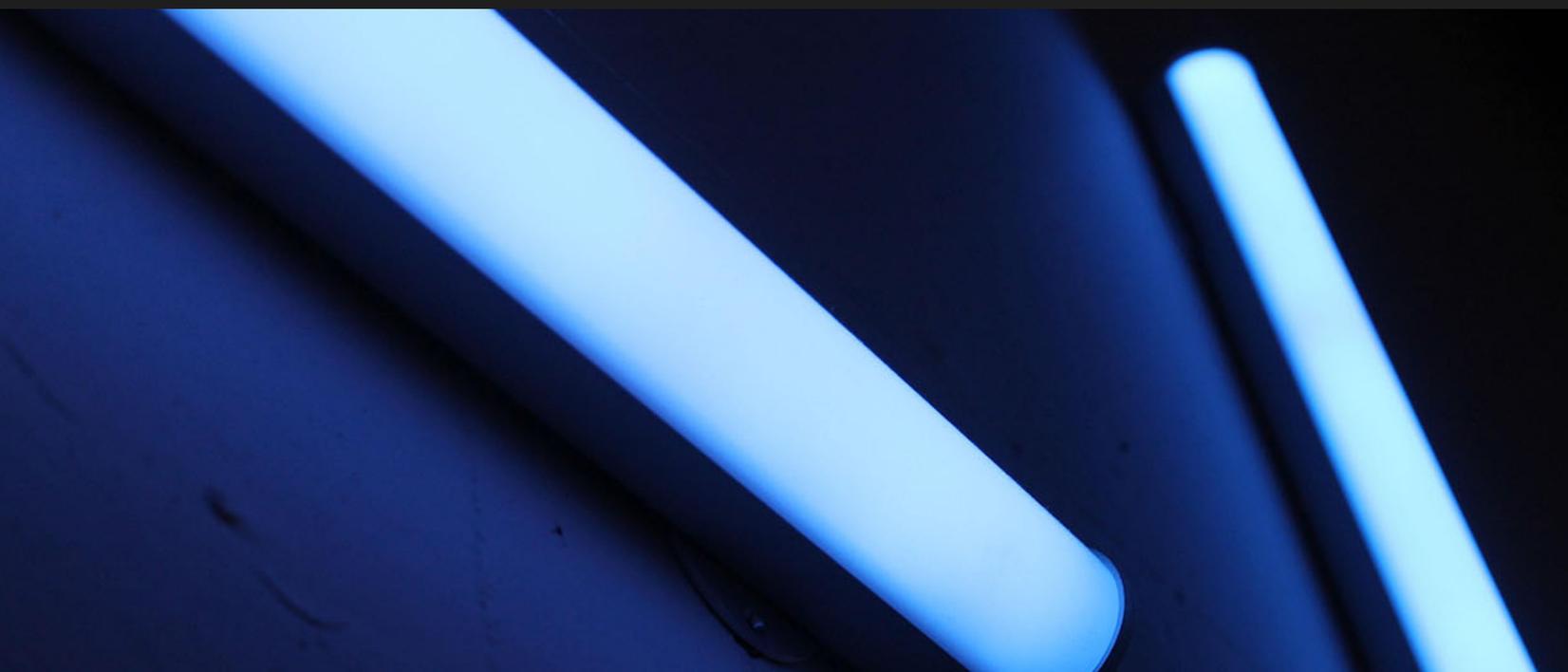
What it is - ultraviolet (UV) light has shorter wavelengths than visible light – the shorter the wavelength, the higher the energy – and of the three UV bands (UVA, UVB and UVC), UVC has the shortest wavelengths – thus has the highest energies, and thus the most potential damage to living cells.

How it works - In humans, UVA light (315-400 nanometer wavelengths) causes skin tanning and contributes to skin ageing and wrinkling; UVB (280-315 nm) penetrates deeper into the skin, causing delayed tanning and burning; it also significantly promotes the development of skin cancers. UVC is the most damaging type of UV light, it can damage DNA, RNA, proteins and cell membranes – killing them – and hence why UVC light is used as a disinfectant.

Similar to ESP, ionizers use a high-voltage wire or carbon fiber brush to electrically charge air molecules, which produces negative ions that attach to airborne particles; the charged particles are then collected either on oppositely charged plates in the air cleaner or become attracted to other surfaces in the room and deposited elsewhere

Considerations – UVC is effective in killing the virus when it has direct exposure to it and there are a few things to consider when using this technology:

- Exposure to humans is a danger to health
- High cost to retrofit and install
- High cost to operate, consuming a lot of energy
- Inactivates but does not remove microbes



The **US FDA** has published advice regarding the use of UVC light against coronavirus and state that “UVC radiation may also be effective in inactivating the SARS-CoV-2 virus, which is the virus that causes the Coronavirus Disease 2019 (COVID-19)... However, currently there is limited published data about the wavelength, dose, and duration of UVC radiation required to inactivate the SARS-CoV-2 virus. In addition to understanding whether UVC radiation is effective at inactivating a particular virus, there are also limitations to how effective UVC radiation can be at inactivating viruses, generally.

- **Direct exposure:** UVC radiation can only inactivate a virus if the virus is directly exposed to the radiation. Therefore, the inactivation of viruses on surfaces may not be effective due to blocking of the UV radiation by soil, such as dust, or other contaminants such as bodily fluids.
- **Dose and duration:** Many of the UVC lamps sold for home use are of low dose, so it may take longer exposure to a given surface area to potentially provide effective inactivation of a bacteria or virus.

UVC radiation is commonly used inside air ducts to disinfect the air. This is the safest way to employ UVC radiation because direct UVC exposure to human skin or eyes may cause injuries, and installation of UVC within an air duct is less likely to cause exposure to skin and eyes.

There have been reports of skin and eye burns resulting from improper installation of UVC lamps in rooms that humans can occupy.”

Additionally, cost outlay to install UVC air disinfection ranges from \$3,500 for an in-room UVC air purifier to over \$10,000 to install a UVC radiation unit inside a building ventilation duct which combined with power consumption costs is not an affordable solution for many.

What it is - Ionizers i.e. negative ion generators, ESPs work by creating a static charge around the airborne contaminants that are floating around your room, to remove them from the air.

How it works - Once charged with static, these particles (dust, allergens, etc,) simply stick to the nearest surface they find. Your air feels fresh because the contaminants are no longer floating around in mid-air, but the fact is those contaminants are now firmly stuck to many of the surfaces of the room such as the walls, furniture, carpets and tops - this is why you often see a ring of black around the base of an ionizer when it has been moved. Similarly, ESPs work by using a corona discharge wire charges incoming particles, which collect on oppositely charged plates.

Considerations

- Many ionisers have risk of ozone production - California banned most ionisers due to risk of ozone production
- Cannot have prolonged exposure to ioniser as it can cause lung damage
- Typically low effectiveness because of very low airflow rates and clean air delivery rates (CADRs)

Many ionisers have the risk of ozone production that can cause lung damage and are not safe to have prolonged exposure to, in fact most ionisers have been banned by California due to risks of ozone production.

The California Air Resources Board has released a fact sheet titled, "**Hazardous Ozone-Generating Air Purifiers**" – here are some excerpts: "Not only are ozone generators ineffective at cleaning indoor air, but inhaling ozone poses serious health risks for humans and animals...ozone is only partially effective at cleaning the air when it is used at extremely high, unsafe levels that pose a serious health risk.

People who buy ozone generators may not be aware that ozone can harm the cells in the lungs and respiratory airways. Exposure to ozone irritates and inflames the lining of the respiratory system. This causes symptoms including coughing, chest tightness, shortness of breath, and impaired breathing. Ozone can worsen asthma symptoms, and may contribute to the development of asthma.

Elevated exposures to ozone can cause permanent lung damage, and repeated exposure can even increase the risk of dying among persons already in poor health. Persons especially vulnerable to health problems from breathing ozone include children and those who already suffer from asthma or other respiratory diseases, including the elderly. There are many experimental studies on animals, including dogs, cats, hamsters and guinea pigs, that show respiratory effects from exposure to ozone. Birds are especially sensitive to the effects of air pollutants, including ozone.”



What it is Spray-based and/or surface disinfectants are a broad range of chemicals – including bleach, hydrogen peroxide and isopropyl alcohol - that are highly effective at killing bacteria, but that also tend to be toxic.

How it works Generally, the bacteria is killed by oxidation – rupturing its cell membrane.

Considerations This ability to oxidise cells could be toxic to humans – e.g. if the disinfectants are swallowed or breathed in.

Spray-based/surface disinfectants - Quaternary Ammonium Compounds (QACs)

- Costly to retrofit and install
- Needs high level of control to disperse
- Strict limits on exposure whilst dispersing
- Toxic to humans

Although quaternary ammonium compounds are widely used as spray-based and/or surface disinfectants, the first extensive study on their toxicity to humans has only just been published on [medRxiv](#); here are some excerpts:

“Humans are extensively exposed to Quaternary Ammonium Compounds (QACs). QACs are ubiquitously used in medical settings, restaurants, and homes as cleaners and disinfectants. They are also used on food and in personal care products as preservatives. Despite their prevalence, nothing is known about the health effects associated with chronic low-level exposure. Chronic QAC toxicity was recently identified in mice and resulted in developmental and reproductive deficits and altered immune function.

Cell based studies show that QACs increase inflammation, disrupt cholesterol synthesis, and decrease mitochondria function. If these studies translate to human toxicity, multiple physiological functions could be affected.

QAC concentrations in humans have not been monitored previously. This study tested whether QAC concentrations could be detected in the blood of 43 random volunteers, and whether QAC concentrations were associated with markers of inflammation, mitochondrial function, and cholesterol synthesis in a dose dependent manner. QAC concentrations were detected in 80% of study participants, and were associated with decreased mitochondrial function and an increase in inflammatory cytokines in a dose dependent manner. Cholesterol synthesis pathway intermediaries were generally increased, indicating disruption in cholesterol homeostasis. This is the first study to demonstrate that chronic exposure to QACs results in measurable concentrations in human blood, and to also demonstrate significant correlations between QAC level and meaningful biomarkers related to health." [Altered Toxicological Endpoints in Humans with Quaternary Ammonium Compound Exposure, medRxiv,](#)



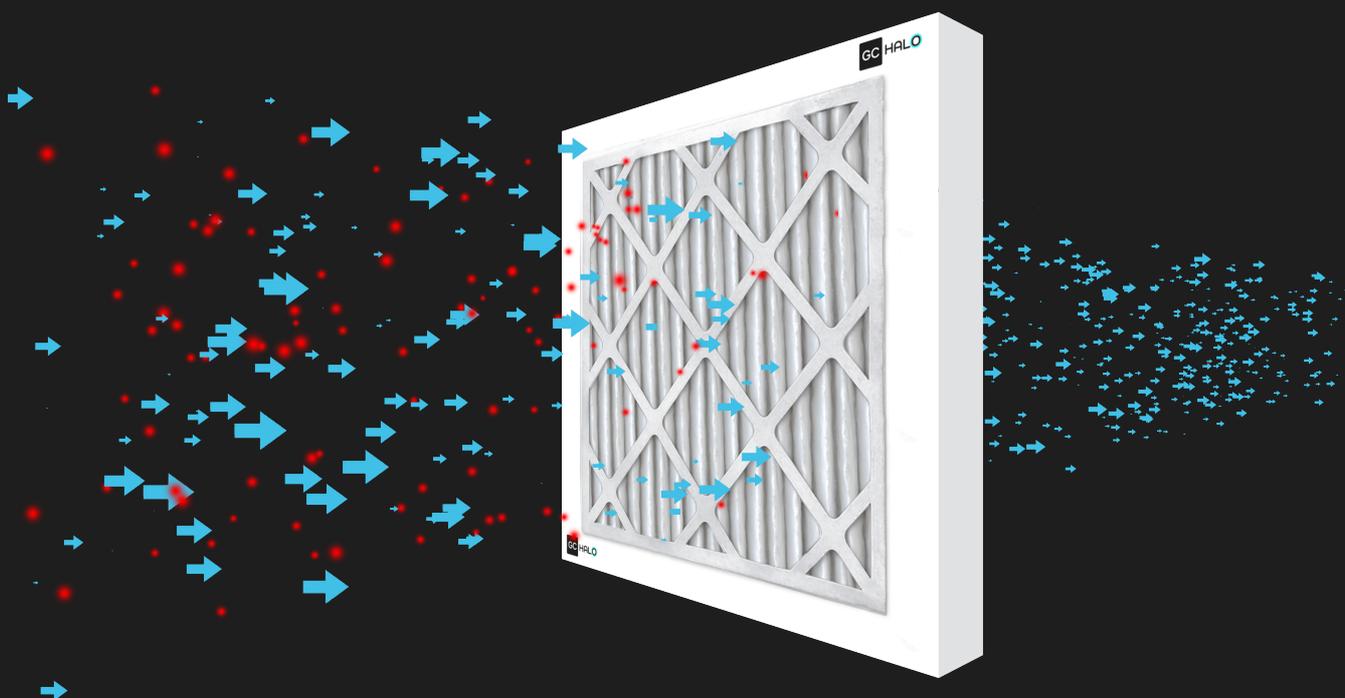
What is it – GC Ink™ is a new, powerful formulation that forms a virucidal and antimicrobial coating on a surface certified to ISO 18184 standards to have at least 99% virucidal efficacy on textiles. GC Ink provides superior, long-lasting protection against viruses and bacteria with broad applications where health, safety and wellbeing are paramount.

How does it work - A formulation that works on a nano-scale, GC Ink has a 'trap-and-kill' nano-chemistry where two nanomaterials – graphene oxide and silver nanoparticles – work together. GC's technology is highly effective because it has a dual-action mechanism: the negatively-charged surface of graphene oxide traps the positively-charged parts of water droplets and the protein spikes on coronavirus; the silver nanoparticles oxidize the lipid membrane protecting coronavirus RNA, thereby killing it.

Considerations:

- Fast, affordable, and effective way of making air cleaner and safer.
- Used as a filter for existing HEPA and air filters
- No retro-fitting - versatile solution, compatible in existing air ventilation systems
- No additional maintenance management – becomes a part of the existing filter and recycled as such
- No reduction in performance of airflow

[Find out more](#)



UVC - Ultraviolet Light

World Health Organisation, "Radiation: Ultraviolet (UV) radiation Q&A"

[Find out more](#)

US FDA, "UV Lights and Lamps: Ultraviolet-C Radiation, Disinfection, and Coronavirus"

[Find out more](#)

US EPA – Residential air cleaners – a technical summary 3rd edition

[Find out more](#)

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Ionizers/Ozone generators/Electrostatic precipitation (ESP)

California Air Resources Board, "Hazardous Ozone-Generating Air Purifiers"

[Find out more](#)

US EPA – Indoor Air Quality (IAQ)

[Find out more](#)

US EPA – Ozone Generators that are Sold as Air Cleaners

[Find out more](#)

US EPA – Residential air cleaners – a technical summary 3rd edition

[Find out more](#)

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Spray-based/surface disinfectants

Dr Terry Hrubec et alia, "Altered Toxicological Endpoints in Humans with Quaternary Ammonium Compound Exposure"

[Find out more](#)

US EPA - About List N: Disinfectants for Coronavirus (COVID-19)

[Find out more](#)

List N Tool: COVID-19 Disinfectants

[Find out more](#)



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